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Particle Physics Division

Mechanical Department Engineering Note

Number: MD-ENG-239 Date: 24 March 2010

Project Internal Reference: none

Project: Lab 5 Extruder Access Platform

Title: Lab 5 Access Platform

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Reviewer(s):

Key Words: Lab 5, Access Platform

Applicable Codes: OSHA regulations: 1910.28(a)3, 1910.28(b)15, 1910.24c

Aluminum Design Manual

International Building Code 5095

Abstract Summary: Stresses are checked to meet OSHA regulations on the guardrail, the flat plate, and the support plates.

CRANE
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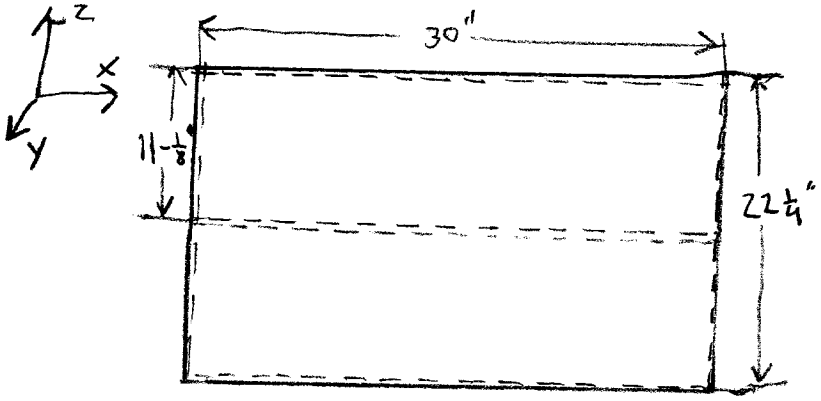
Flat Plate

→ All materials Al. T6 6061

→ OSHA requirement: Platform must allow 4× intended load (1910.28(a)(3))

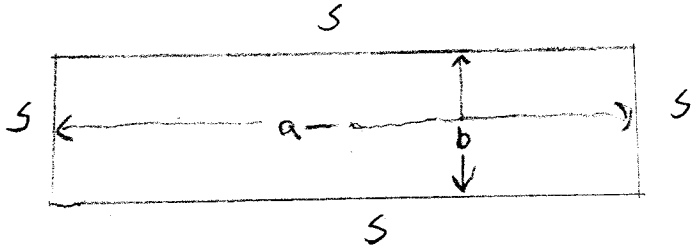
→ Dashed line supports are ¼" thick

→ Formulas from Roark's formulas for stress and strain, 6th ed.
- Table 26, Case 1a
- Uniform load over entire plate, Q = 250 #/ft²



At center; $\sigma_{max} = \frac{\beta q b^2}{t^2}$ $\quad R_{max} = \gamma q b$

$y_{max} = \frac{-\alpha q b^4}{E t^4}$



$\frac{a}{b} = \frac{30}{11\frac{1}{8}} = 2.7$;

$\beta = .68244$

$\alpha = .12815$

$\gamma = .504$

$q = 250 \frac{\#}{ft^2} / 144 \frac{in^2}{ft^2} = 1.77 \frac{lbs}{in^2}$

$t = \frac{1}{4}"$; $E = 10^7$ psi

$$\sigma_{max} = \frac{(.68244)(1.77)(11.125)^2}{(.25)^2} = 2446 \text{ psi: ok}$$

$$y_{max} = \frac{(.1285)(1.77)(11.125)^4}{(10^7)(.25)^4} = .0933" \text{ ok}$$

$R_{max} = (.504)(1.77)(11\frac{1}{8}) = 9.9 \frac{lbs}{in}$ at center of long edge

$9.9 \frac{\#}{in} \times 30 in = 297 \#$

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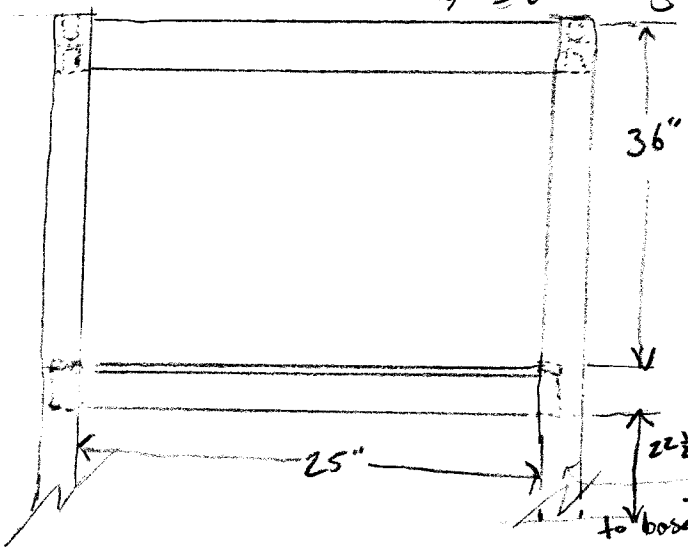
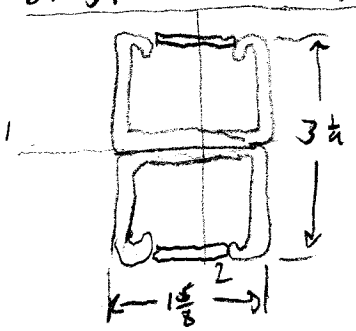
Guard rail

→ OHSA requirements: → withstand 200 lbs at top in any direction
→ 36" < height < 42" → 1910.23(b)(5)



unistrut section P1001

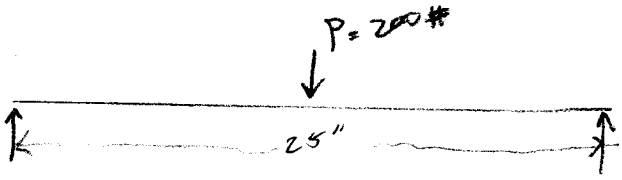


$A = 1.112\ in^2$
$I_{22} = .472\ in^4$
$S_{22} = .580\ in^4$

Legs → max allowable load at slot face: 6360 lbs to avoid (@ 24") buckling. Actual load applied at long edge; w/ $I_{22} < \frac{1}{2} I_{11}$ → max load at long edge set = 6360/3 = 2120 lbs

horizontal rail

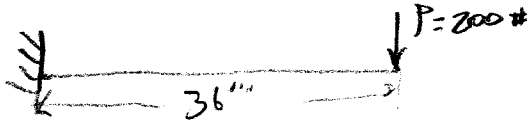
→ Load on weak axis (22)



$M_{max} = \frac{Pl}{4}$, $\sigma_{max} = \frac{M_{max} c}{I_{22}}$

$M_{max} = \frac{200(25)}{4} = 1250\ \#\cdot in$; $\sigma_{max} = \frac{1250(\frac{1\frac{5}{8}}{2})}{.472} = 2152\ psi$ ok

vertical rail



$M_{max} = Pl$; $\Delta_{max} = \frac{Pl^3}{192 E I_{22}}$

$M_{max} = 200\# \times 36" = 7200\ in\#$ $\sigma_{max} = \frac{7200(\frac{1\frac{5}{8}}{2})}{.472} = 12{,}394\ psi$

$\Delta_{max} = \frac{200(35\frac{1}{2})^3}{192(10^7)(.472)} = .0099"$ ok

→ Unistrut max concentrated load:
(3130# uniform load limit from unistrut General Engineering Catalog)

load factor
24" span = 3130# × .5 = 1565# ok
36" span 3130# × .12 = 375.6# ok

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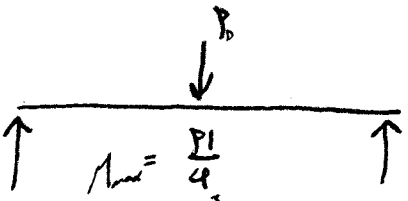
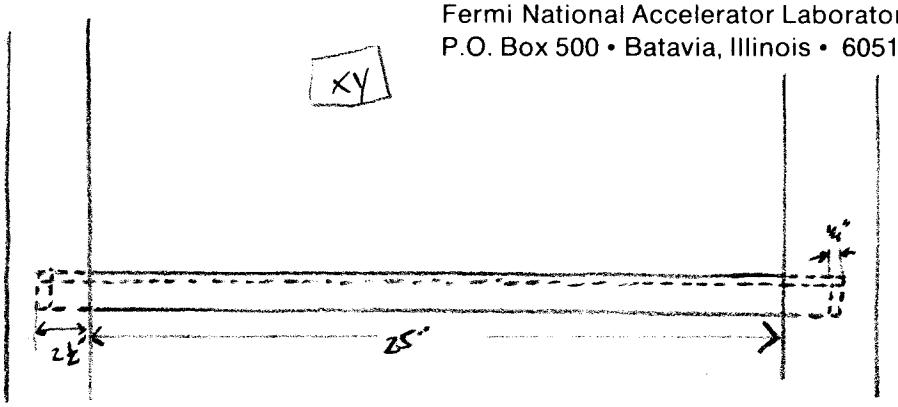
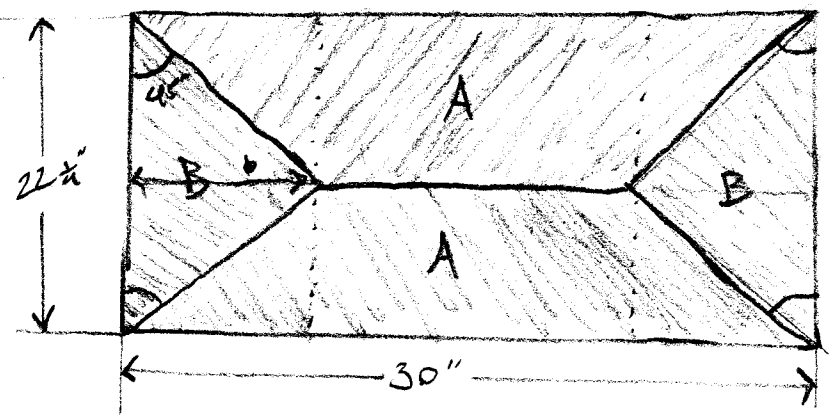
Support Plates





→ Load Distribution (Tributary area)



250 $\frac{lb}{ft^2}$

b = 11¼"

$A_B = \frac{1}{2}bh = \frac{1}{2}(11\frac{1}{4})^2 = 247\ in^2$

$A_B = 1.719\ ft^2$

$A_A = (A_T - 2A_B)/2$

$= [(22\frac{1}{4} \times 30) - 2(247)]/2 \times 144$

$A_A = 0.602\ ft^2$

$P_A = 0.602\ ft^2 \times 250\ \frac{lb}{ft^2} = 150.5\ lb$ $\qquad M_A = \frac{(150.5)(25)}{4} = 940.6\ in \cdot lb$

$P_B = 1.719\ ft^2 \times 250\ \frac{lb}{ft^2} = 429.75\ lb$ $\qquad M_B = \frac{(429.75)(22\frac{1}{4})}{4} = 2390.5\ in \cdot lb$

$\sigma_{max} = \frac{M_{max}c}{I} = \frac{(2390.5)(\frac{1}{2})}{(.02083)} = 57,381\ psi$

$SL = \frac{a}{t}\sqrt{L/d} = \frac{1}{.26}\sqrt{25/1} = 20$; $3_1 .13 < SL = 20 < 3_2 = 29$ ✓

$\sigma_{allowable} = 40.5 - .936L = 40.5 - .93(20) = 21,900\ psi$

$\sigma_{max} > \sigma_{allowable}$ → more support needed

$\sigma_A = \frac{(940.6)(\frac{1}{2})}{(.02083)} = 22,564\ psi$

$21,900 = \frac{(2390.5)(\frac{1}{2})}{I_{needed}}$ → $I_{needed} = .0546\ in^4$

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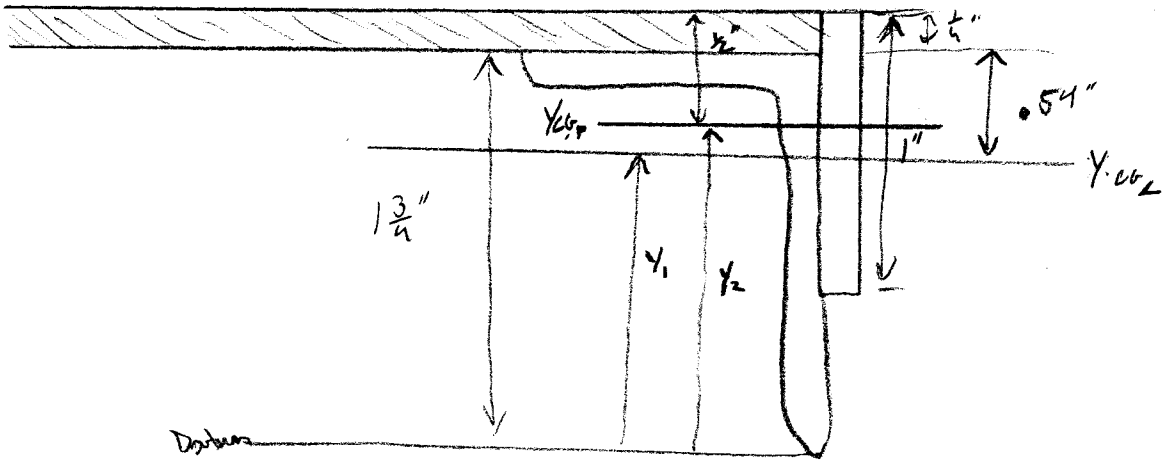
→ Add angles (all edges) $\angle 1.75 \times 1.25 \times .125$ $I_x = .108\ in^4$

$I_{Total} = .108 + .02083 = .12883\ in^4$



$$Y_{CG_{Total}} = \frac{Y_1 W_L + Y_2 W_p}{W_L + W_p} = \frac{1.26"\left(.42\frac{lb}{ft} \times \frac{25"}{12}\right) + 1.5"\left(1" \times .25" \times 25" \times .098\frac{lbs}{in^3}\right)}{.875 + .6125} = 1.35"\uparrow$$

or .65" below top of top plate

$M_{max} = 2391\ \#\cdot in$; $\sigma_{max} = \frac{2391(.65)^*}{.12883\ in^4} = 12{,}064\ psi$ ok

$\delta_{max} = \frac{297(25)^3}{192(10^7)(.12883)} = .0188"$ ok

→ Total length of angles same as support plates

→ Maximum Load before angles are installed ⇒ $\frac{P(25)}{8}(t) = 21{,}900\ psi$

$P = 291$ lbs max at edge w/o extra support angles

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Welds

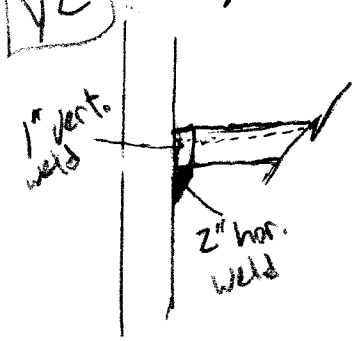
→ Filler rod assumed to have an allowable stress of at least 4.5 ksi (AL 4043 filler rod)

→ All welds are assumed to be at least 3/16"

→ One corner where the platform is supported has the least amount of weld length

support plates

YZ



throat area: $(3/16)(.707)(3") = .3977 in^2$

→ Apply 1000# load at one corner

$$\sigma = \frac{1000\#}{.3977\ in^2} = 2514\ psi$$ ok

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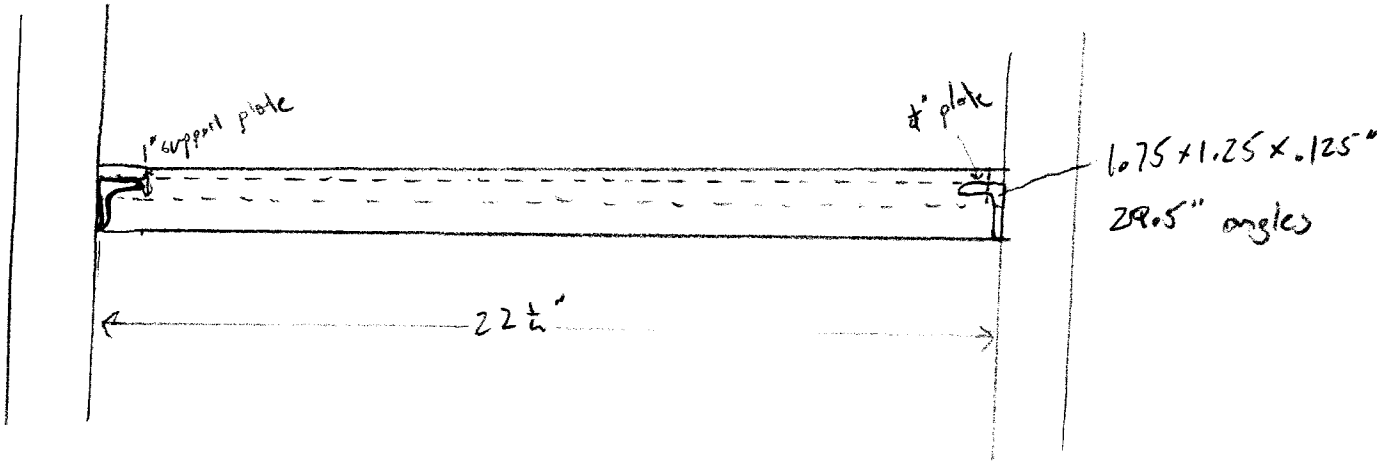
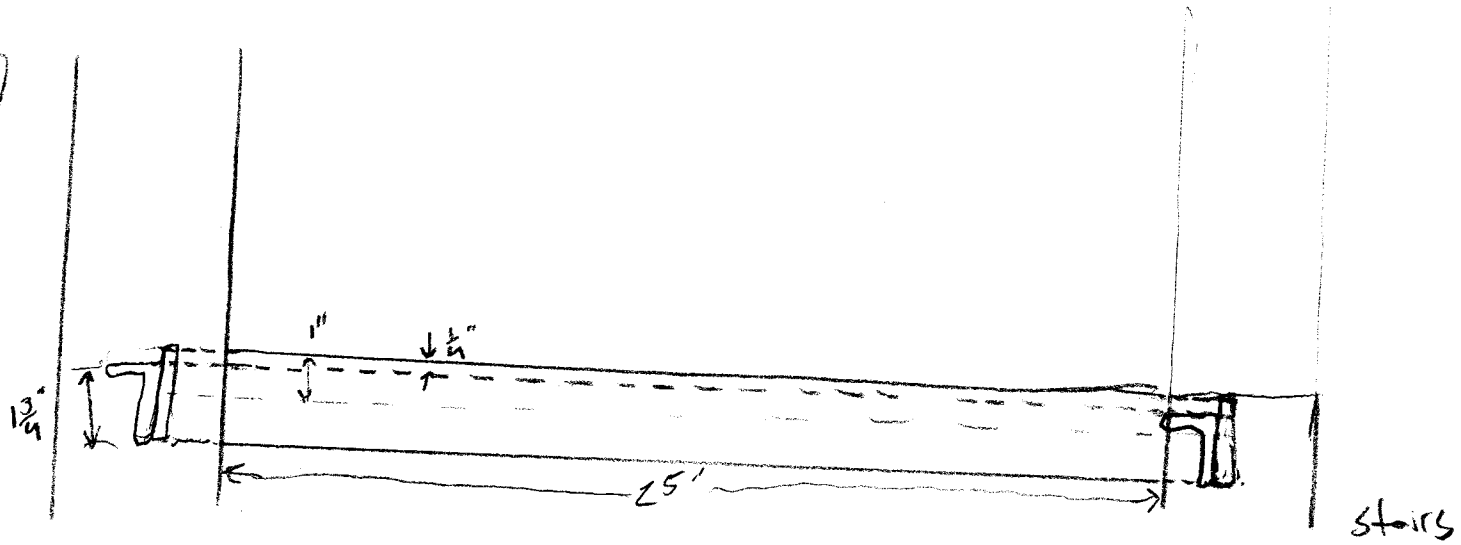
YZ



XY



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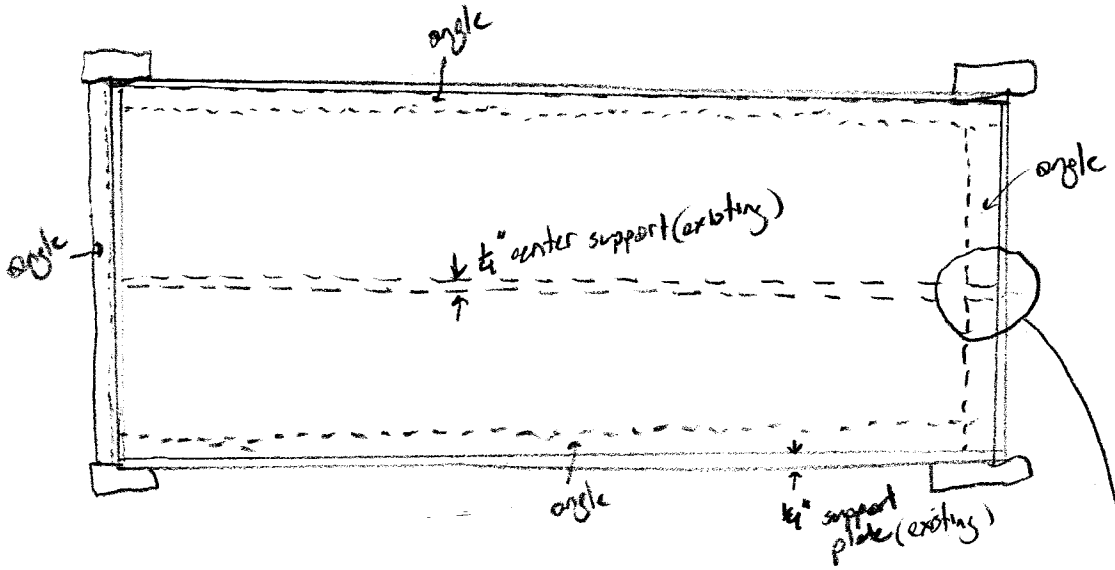

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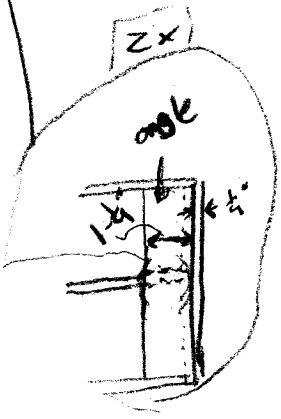


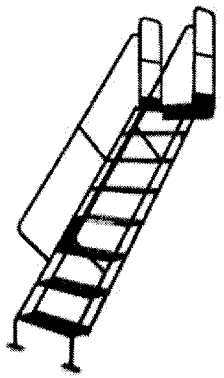
1-¼" of center support plate to be removed to fit angle

Stairway, H 60 In, Perforated Step

Material Handling > Ladders, Platforms and Scaffolding > Stair Units

Access Stairway, Industrial, Load Capacity 450 Lb, Deck 24W x 10D, Platform 24W x 10D, Height to Platform 60 In, Number of Steps 6, Perforated Step, Construction Steel, Standards OSHA and ANSI

Grainger Item #	2NJW9
Price (ea.)	**$411.25**
Brand	TRI-ARC
Mfr. Model #	WLIS106246
Ship Qty.	1
Sell Qty. (Will-Call)	1
Ship Weight (lbs.)	215.0
Usually Ships**	From mfr. w/in 4 bus. days
Catalog Page No.	1614
Country of Origin	USA



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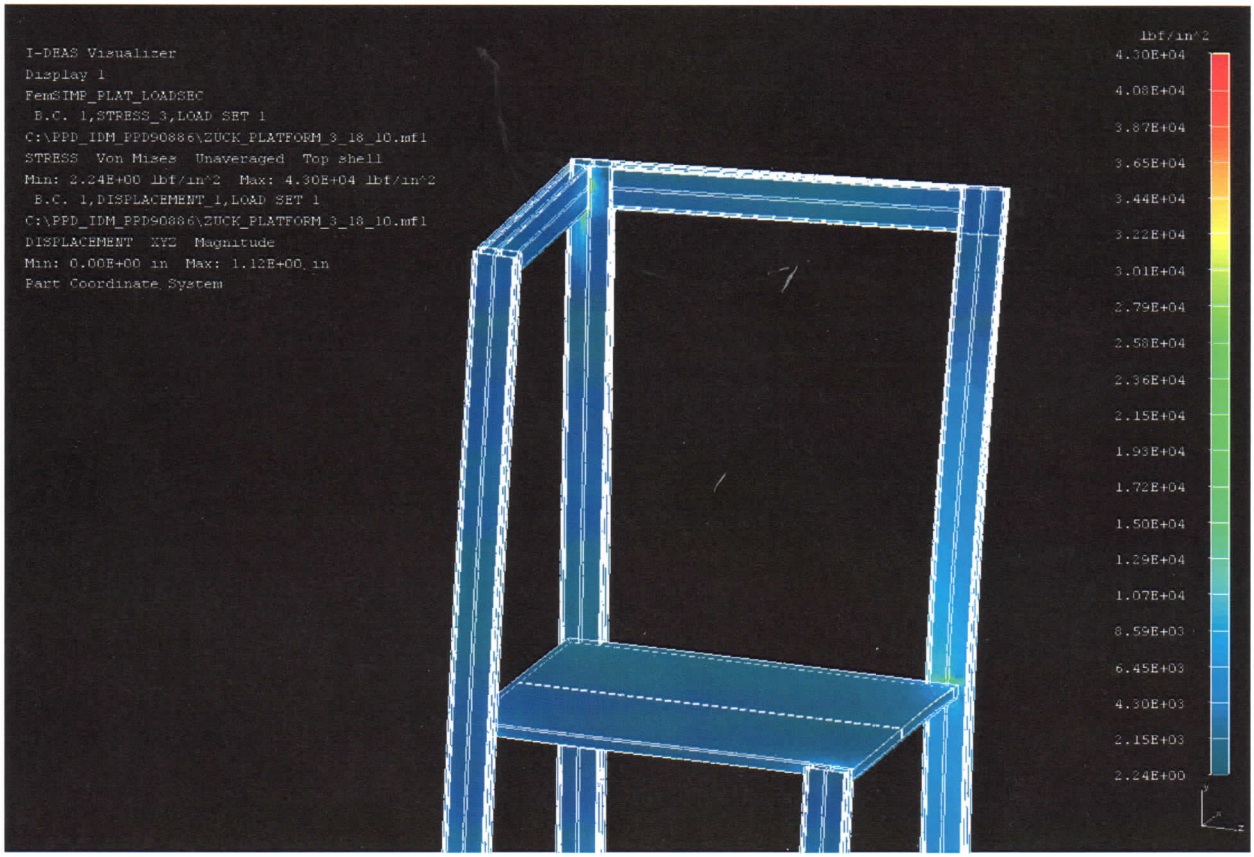
Tech Specs | Additional Information | Compliance & Restrictions | MSDS | Required Accessories | Optional Accessories | Alternate Products | Repair Parts

Item	Access Stairway
Type	Industrial
Load Capacity (Lb.)	450
Deck	24W x 10D
Platform	24W x 10D
Height to Platform (In.)	60
Number of Steps	6
Step	Perforated
Construction	Steel
Standards	OSHA and ANSI

Without extra support angles



200 lb load on top corner of guardrail

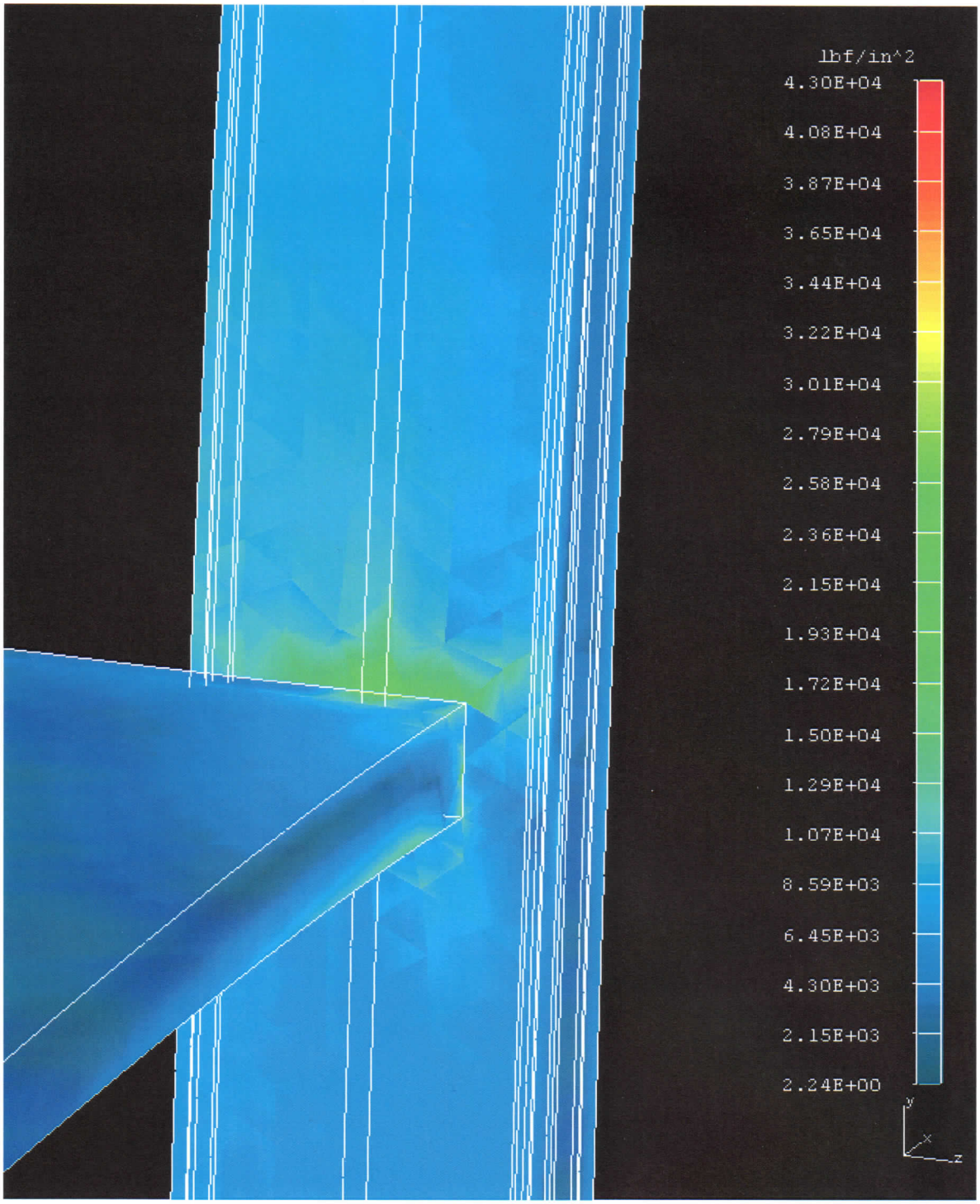
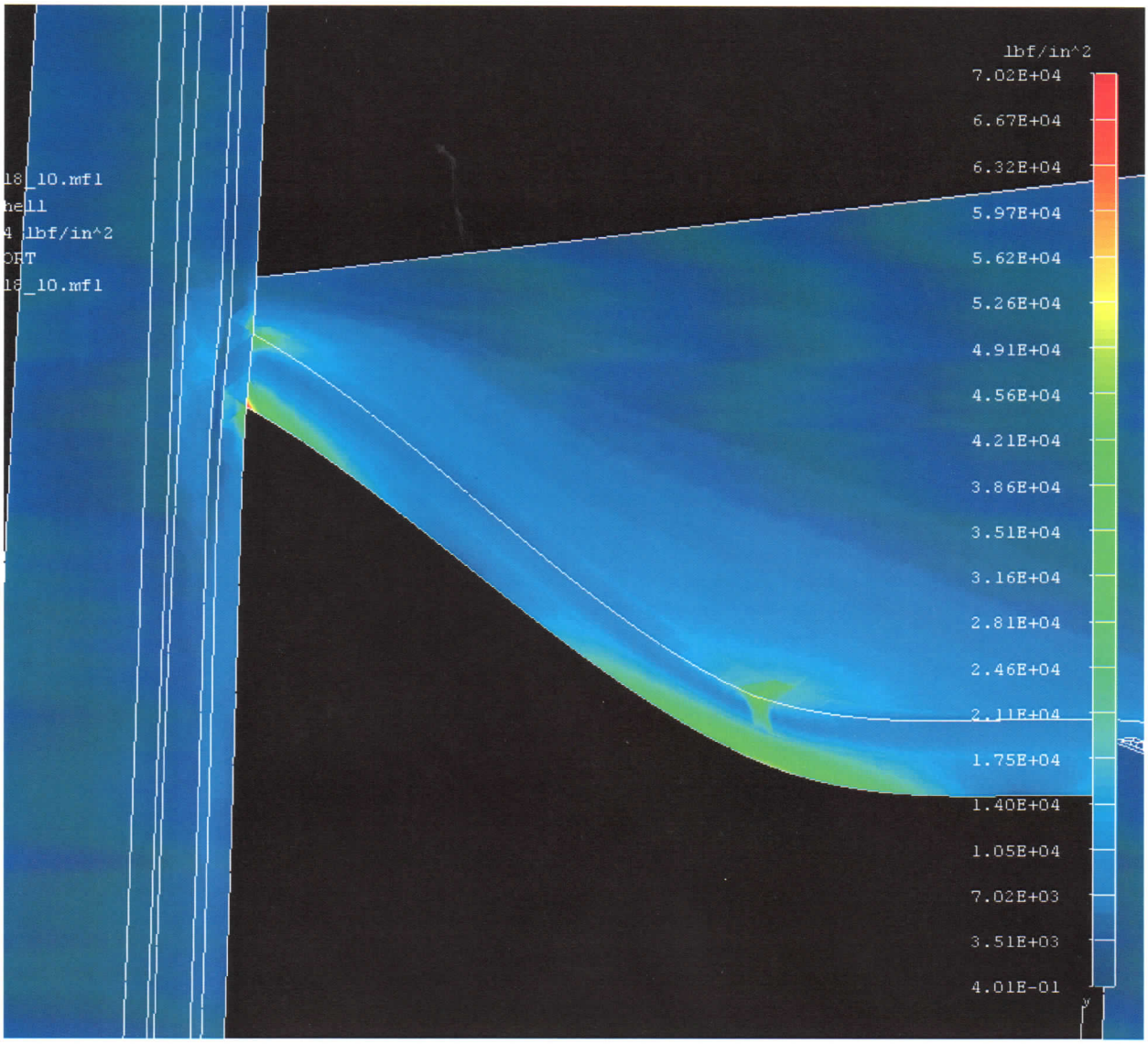
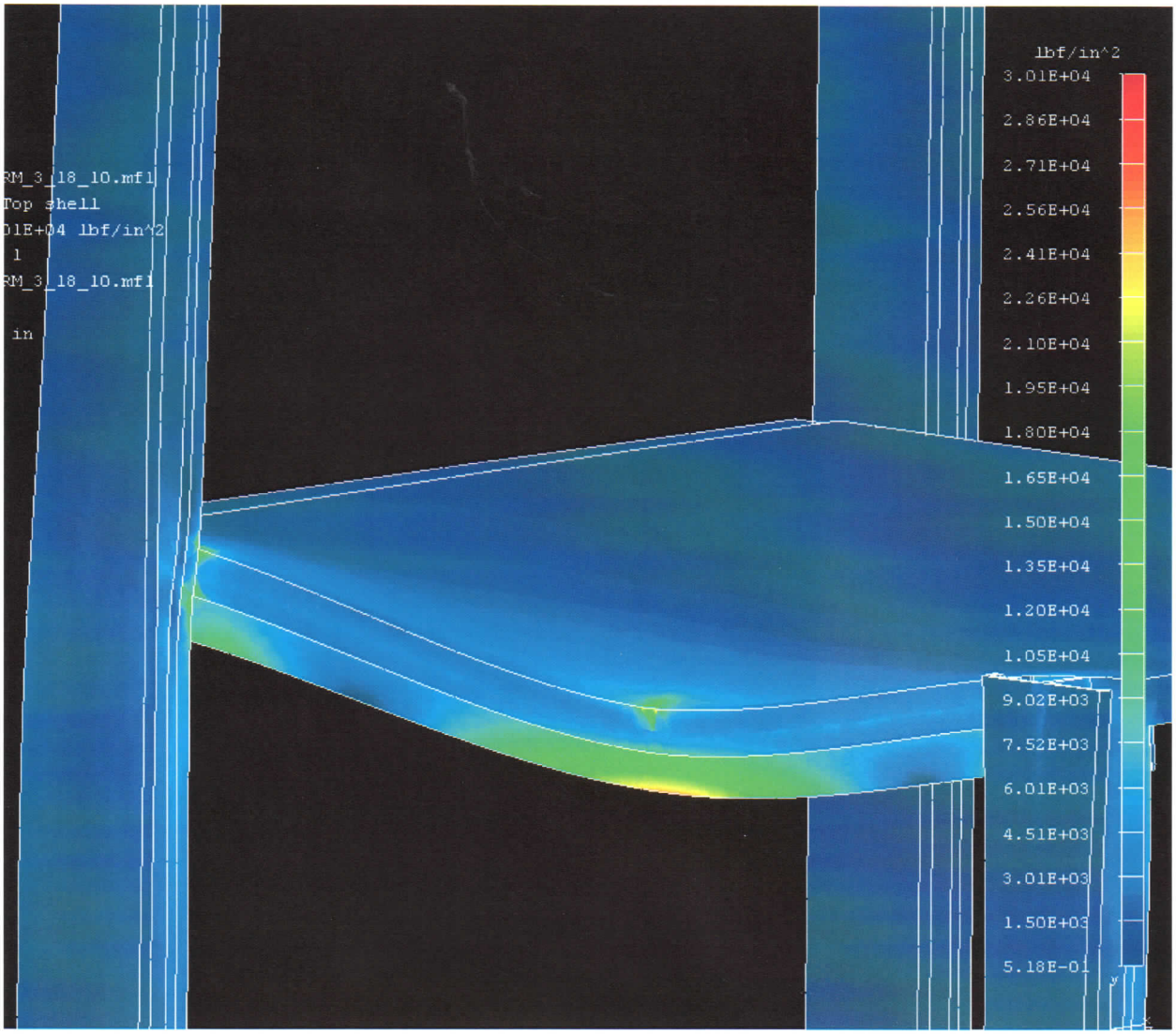


Plate connection from above 200 lb rail load, stress at the connection is up to 24,000 psi in the local area

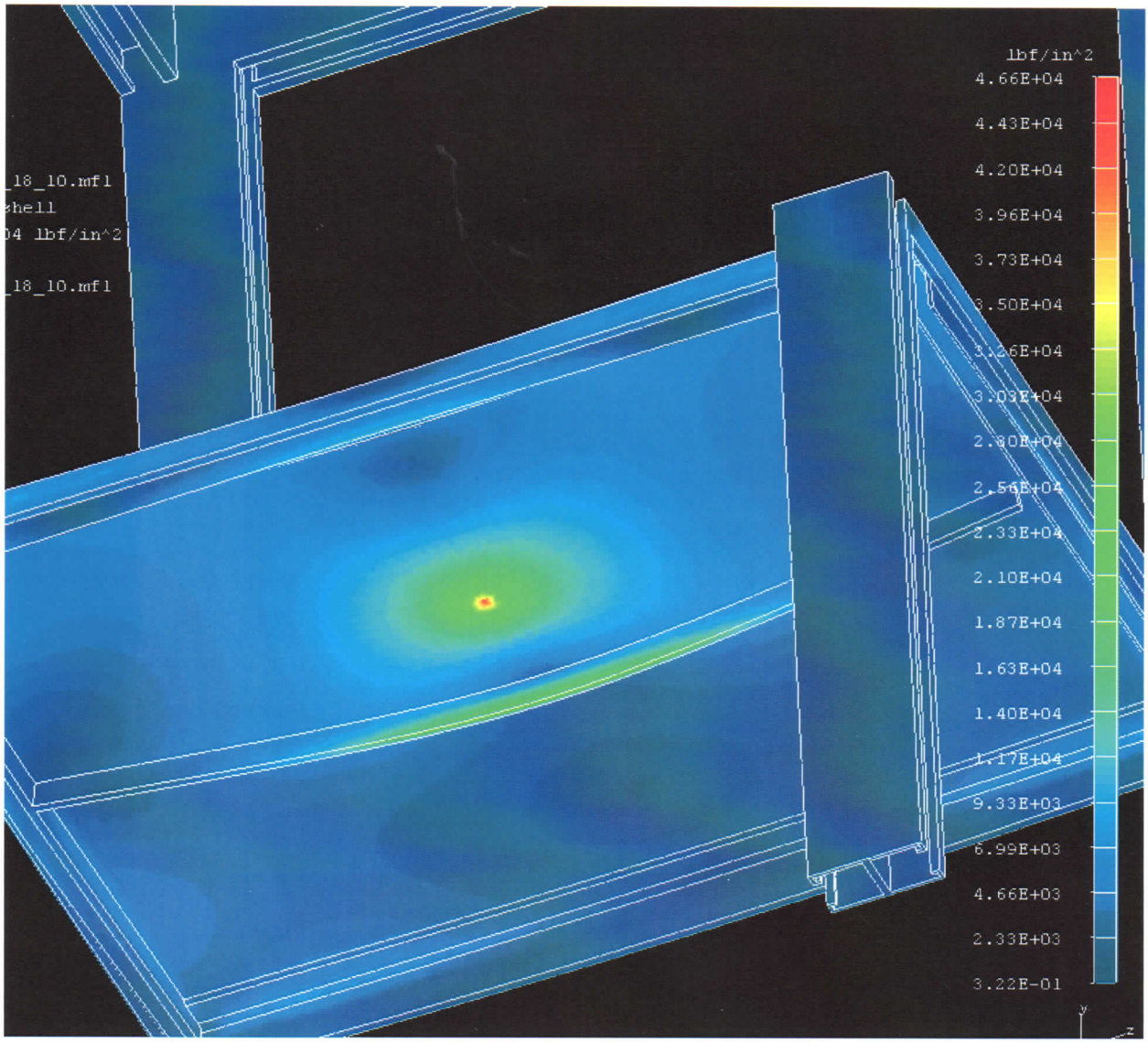


1000 lb load on longer side 1''x0.25''support plate, stresses are too high at up to 45,000 psi

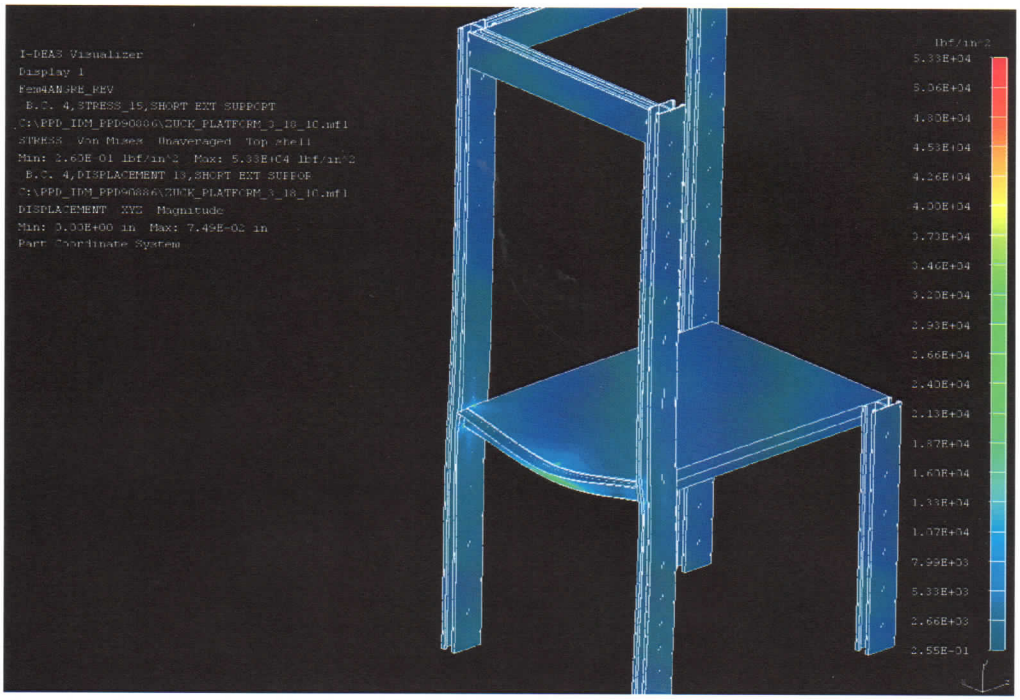
With extra support angles



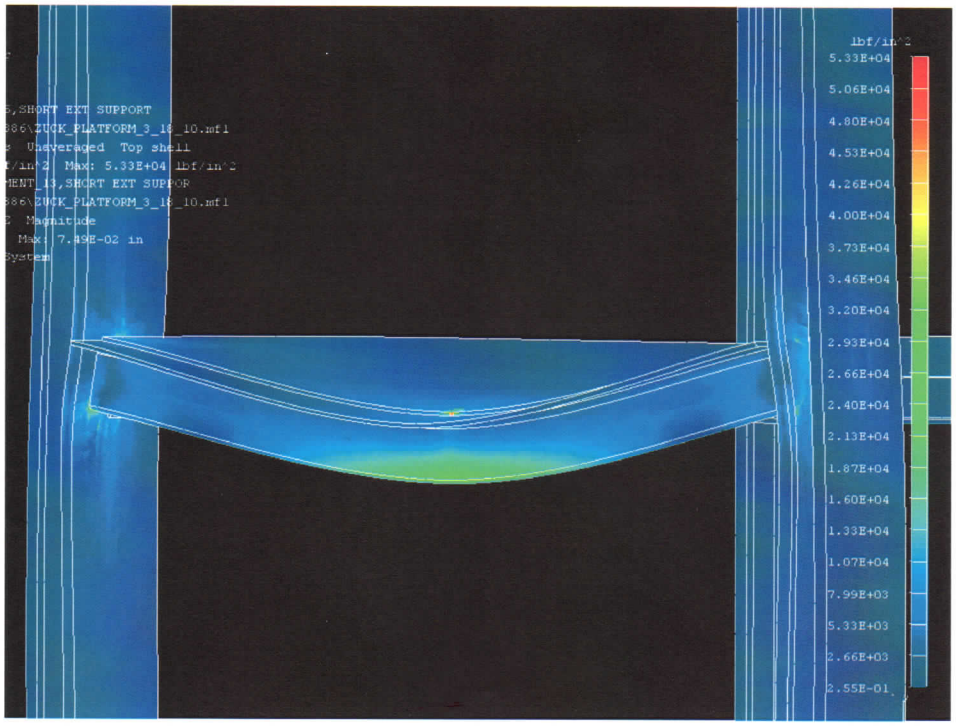
1000 lb load on the longer side support with angle, with the stress reduced to below the allowable limit.



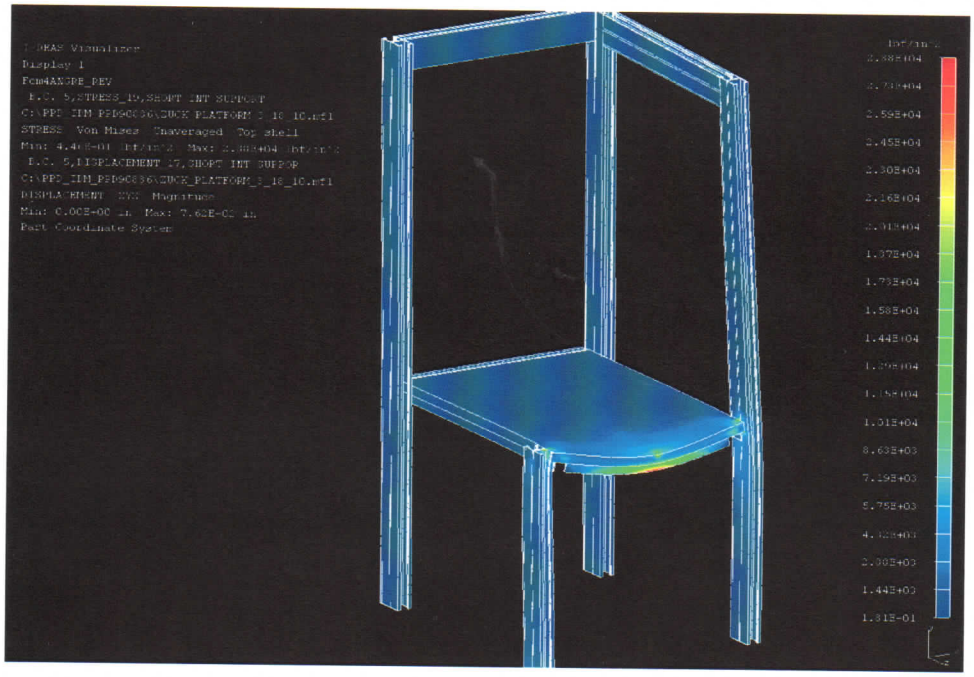
1000 lb point load centered in half the unsupported plate, main stresses are up to 24,000 psi



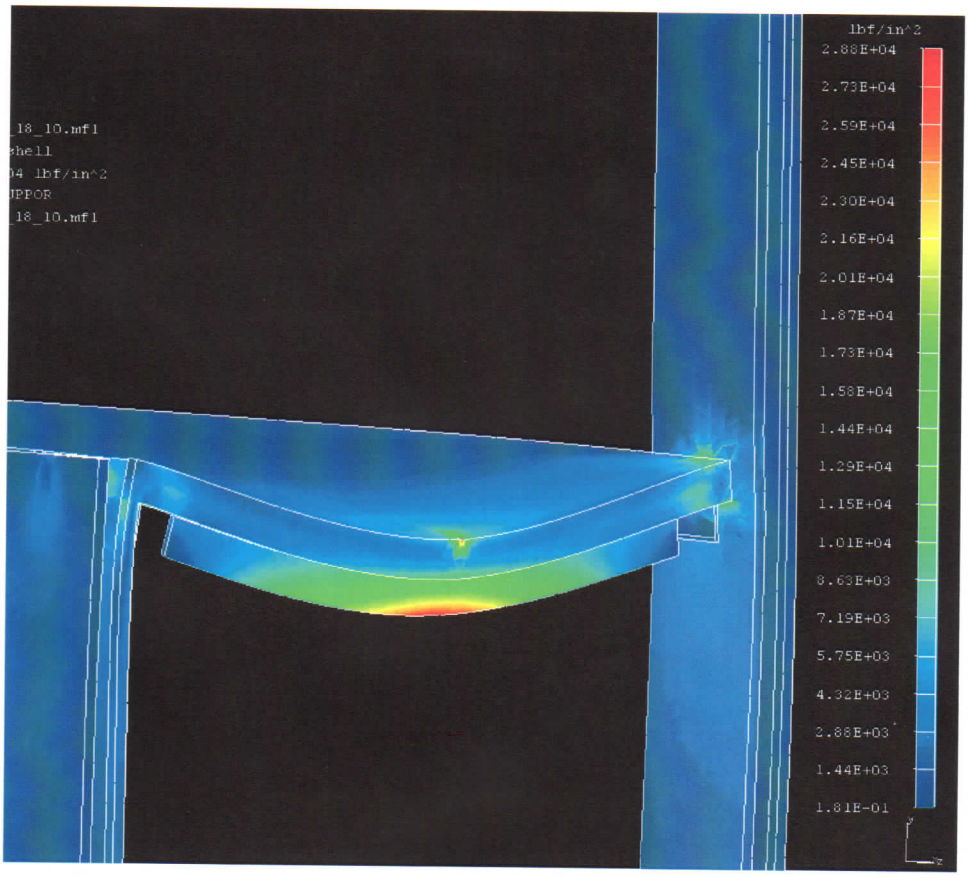
1000 lb load on shorter support plate bolted to the outside of the ¼" support plate with stress less than allowable



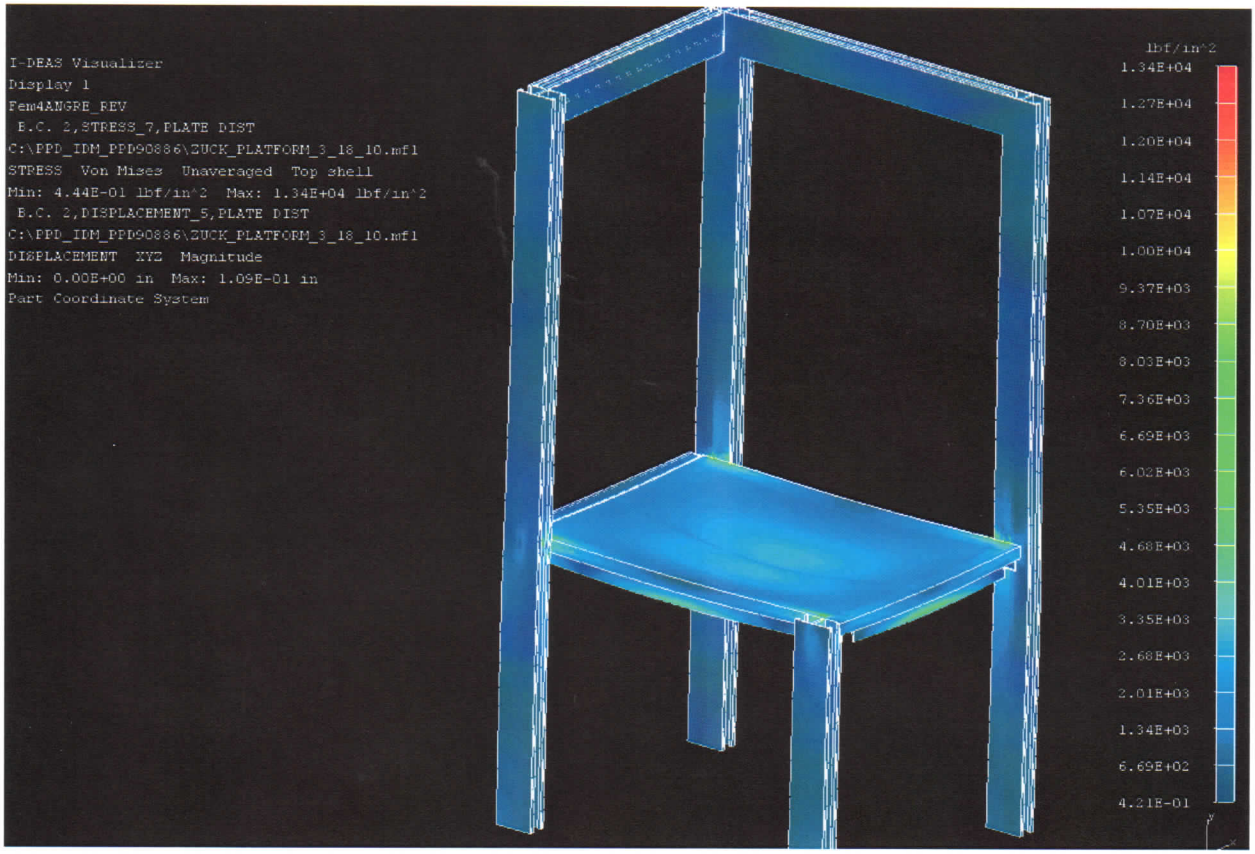
Close up of max stress on the short support as shown above



1000 lb load on shorter support plate (stairway side) bolted to the inside of the support plate with stress less than allowable



Close up of max stress on stairway side short support as shown above



250 lb/ft^2 load on the plate with all stresses less than allowable